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D. E. SALMON, D. V. M., CHIEF OF BUREAU.

NECROTIC STOMATITIS.

WITH SPECIAL REFERENCE TO ITS OCCURRENCE IN

CALVES (CALF DIPHTHERIA)

AND

PIGS (SORE MOUTH).

BY

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., February 1, 1905.

SIR: I have the honor to transmit herewith a manuscript on "Necrotic stomatitis, with special reference to its occurrence in calves (calf diphtheria) and pigs (sore mouth)," by Dr. John R. Mohler and Dr. Geo. Byron Morse, both of the Pathological Division of this Bureau.

It is definitely known that this disease has been in this country during the last three or four years, and it is probable that it has been present a much longer time. It affects calves, pigs, adult cattle, lambs, monkeys, kangaroos, rabbits, dogs, and chickens, but in this country it has so far been reported for calves and pigs only. The percentage of losses varies greatly, but it is always large.

I recommend that this manuscript be published as a bulletin of the Bureau series.

Respectfully,

D. E. SALMON,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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WITH SPECIAL REFERENCE TO ITS OCCURRENCE IN CALVES (CALF DIPHTHERIA) AND PIGS (SORE MOUTH).

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INTRODUCTION.

The vestibular character of the mouth in its relation to the general organism makes any disease of the oral cavity an important matter. Mechanic, chemic, and thermic influences may each play a part in the production of various disturbances of its mucous membrane, but the most frequently operative of all causes—and most serious, too—are the microorganismal. It is these last which render any form of stomatitis serious and constitute the real source of danger in the grave forms. Not the least interesting in this last group—and, as we shall show, of considerable economic importance, although until recent years not recognized in this country—is the affection to which we have given the name "necrotic stomatitis." Owning similar predisposing conditions and recognizing a common etiologic agent, its occurrence has been noted in calves, pigs, adult cattle, lambs, monkeys, kangaroos, rabbits, dogs, and chickens. In this country it has been reported up to the present time only among calves and young pigs, being probably more prevalent among the latter. For this reason and because our investigations in this disease have been limited to cases occurring in these two species only, the following pages will deal with necrotic stomatitis of calves and of pigs.

NAME AND SYNONYMS.

Necrotic stomatitis of calves has been known generally under the unfortunate term of "calf diphtheria." Diphtheria has a specific cause (Klebs-Löffler bacillus) and a definite histologic picture, both of which are lacking in necrotic stomatitis. The name "calf diphtheria"

is therefore a misnomer. The pathologic process in necrotic stomatitis always presents the picture of a diphtheric inflammation plus caseation—that is to say, an inflammation characterized by the production of a membrane, which, as an essential feature of the disease process, undergoes cheesy degeneration. Since this progressive necrosis is caused by the necrosis bacillus, the origin of the term "necrotic stomatitis" is self-evident. This disease in calves has also been termed gangrenous stomatitis, ulcerative stomatitis, malignant stomatitis, tubercular stomatitis, diphtheric patches of the oral mucous membrane, necrosis diphtherica caseosa, stomatitis diphtherica multiplex, and stomatitis membranacea diphtherica. In pigs the affection has been designated ulcerative stomatitis, sore mouth, and canker of the mouth.

Definition.

Necrotic stomatitis is an acute, specific, highly contagious inflammation of the mouth, occurring enzootically in many species of animals and characterized locally by the formation of ulcers and caseo-necrotic patches and by constitutional symptoms, chiefly toxic. The disease is in no way related to diphtheria of man.

Historical Review and Geographical Distribution.

During the last few years farmers and cattlemen of this country have noted the increasing occurrence of sore mouth among the young animals of their herds. Instead of healing of themselves, as the usual forms do, these cases, if untreated, die. Careful study of some of them has resulted in their identification with cases first reported by Dammann[9a] in 1876 from the shore of the Baltic. His model clinical investigations, making the description of the disease suitable for to-day, and his accurate postmortem findings were marred by subjection to the then dominating assertion of Eberth, "without micrococci no diphtheria." Finding micrococci everywhere present in the diseased tissues of the mouth, and failing to recognize the fatal results in his experimental inoculations as due to septicemia, Dammann pronounced the disease identical with diphtheria in man. To what extent the malady occurred before his time it is difficult to determine, but from the fact that his clinical observations were soon confirmed by a number of contemporary veterinarians, it is probable that at the time of his writing it was not very uncommon.[15] In 1878, Blažeković[5] gave an extensive report of sixteen cases (fourteen fatal) of calf diphtheria in Slavonia, and, in 1879, Vollers,[66] adopting Dammann's theory, recorded four cases of the same disease in Holstein. Near the close of 1880, Lenglen[41] described quite accurately the local manifestation and gen-

[a] The figures refer to the bibliography at the end of this bulletin.

eral symptoms of the disease as noted by him in a series of ten cases in the northern part of France. Under the title of gangrene of the mouth in young calves, he identified the disease with gangrenous stomatitis, or noma, in children, and, as predisposing causes, associated the eruption of the teeth with bad sanitary and dietetic conditions. His article attracted the attention of MacGillivray,[46-50] of Banff, Scotland, who published several articles during 1881–82, describing his experiences with the same disease, and asserting that it was a tubercular stomatitis rather than diphtheritis, or gangrenous stomatitis. During these two years there entered into the controversy thus started in the Veterinary Journal and the Veterinarian, the following persons with reports of their own cases: Campbell,[6] Cole,[8] Fleming,[16] Gunn,[25] James,[28] Metherell,[51] Smith,[63] and Steel.[64] In 1884, Löffler[42] isolated and described the bacillus of human diphtheria, thus destroying all previous theories as to the cause and relation of micrococci with that disease. Pursuing similar investigations, he the same year isolated from diseased tissues in cases of so-called calf diphtheria a long slender thread-like bacterium, which he described and demonstrated as the cause of this affection. Löffler thus proved diphtheria of man absolutely distinct etiologically from that disease, so called, in calves. In 1903, Mettam[52] observed this affection in Ireland in the calves of the province of Munster and in Dublin, while McFadyean[45] has mentioned his familiarity with its prevalence for some years in various sections of England. We have no exact knowledge of the existence of the disease in this country prior to 1897, when it was recognized by one of us in southwestern Texas. It was later observed in rather serious outbreaks in 1902 and 1903 in Colorado, Wyoming, and South Dakota.

Bang,[1] in his notable work on the necrosis bacillus, was the first to announce this parasite's causative relation to the deep necroses often affecting the mouths of hogs. However, Johne,[32] in his pathological reports for 1890, seems to have recognized the disease in pigs, although it was not until 1893 that Schlegel,[59] working in conjunction with Johne,[33] proved the relationship of the *Bacillus necrophorus* to diphtheric inflammation of the tonsils, pharynx, and larynx in hogs. Kitt[35] was also able to recover the causative agent of this disease from the diphtheric lesions of the larynx and pharynx of calves and pigs in 1893. In 1903, Lauritsen[40] described a necrotic inflammation of the mouth in young pigs, believing, though not demonstrating, *Bacillus necrophorus* to be the cause.

The outbreaks of this disease in pigs, which we were enabled to study, appeared in an enzootic form in western Tennessee, and, at the Athenia quarantine station, among a herd of young Berkshire hogs recently imported, from which cases the *Bacillus necrophorus* was recovered.

ETIOLOGY.

Necrotic stomatitis is due to a specific infection. It is an inoculation disease and occurs as a result of the already abraded lining membrane of some part of the oral cavity being invaded by the *Bacillus necrophorus*.

A.—PREDISPOSING CONDITIONS.

These prepare the nidus for the active agent. The necrosis bacillus will not develop on a normal mucous membrane; its invasion is always secondary. Opportunity for infection of the mouth is afforded by a catarrhal inflammation of its lining, by a break in the integrity of its protective covering, or by the rôle played by the bacterial flora of the mouth in damaging its cells and tissues. Here may be mentioned, also, irritant foods, rough forage, very hot or very cold drinking water, chronic and debilitating diseases, and damp, unsanitary pens. Furthermore, as will be pointed out later, some predisposition appears necessary for the development of necrotic stomatitis. In part, this is individual, for whereas the disease is distinctly one of young animals, some of these are more highly susceptible than others.

B.—ACTIVE AGENT (BACILLUS NECROPHORUS).

BACTERIOLOGY.[a]

NAME.

This organism has been variously known as *Bacillus der Kälberdiphtherie* (Löffler),[42] 1884; *Bacillus diphtheriæ vitulorum* (Flügge)[18]; *Bacillus necrophorus* (Flügge),[18] 1886; *Bacillus filiformis* (Schütz),[61] 1887; *Nekrosebacillus* (Bang),[1] 1890; *Streptothrix cuniculi* (Schmorl),[60] 1891; *Actinomyces cuniculi* (Gasperini),[22] 1892; *Bacillus necroseos* (Salomonsen),[58] 1894; *Bacillus des Kälbernoma* (Ritter),[57] 1895; *Streptothrix necrophora* (Kitt),[34] 1899; and *Actinomyces necrophorus* (Lehmann & Neumann), 1899.

Until authors are more agreed as to the possession by this organism of the character of branching, a feature not observed during the course of our investigations, it will be well to consider it as belonging to the Bacteriaceæ and allow priority to designate it *Bacillus necrophorus* (Flügge).

HISTORY.

First observed by Koch,[36] it was not isolated and described until Löffler, in 1884, demonstrated it as the cause of the disease erroneously called by Dammann[b] calf diphtheria. It remained for Bang to recog-

[a] It is with pleasure that we acknowledge our indebtedness to Dr. B. Bang and Dr. W. Ernst for sending us cultures of *Bacillus necrophorus* with which to compare our organism.

[b] Without doubt Dammann, on page 12 of his article, in his description of the tangled network of fibrin threads in the deeper layers of the pseudomembranous deposits, really refers to the filaments of *Bacillus necrophorus*.

nize its varied activities in the production of coagulation necrosis and describe it as the Nekrosebacillus. A year later Schmorl made public his careful investigations of a spontaneous rabbit disease in his laboratory, resulting in the recovery of this same organism which he, either not knowing of Löffler's and Bang's labors or failing to identify his organism with theirs, called *Streptothrix cuniculi*. Since then numerous investigators have confirmed the work of the foregoing scientists and demonstrated a still wider sphere of pathogenic relationship, the latest being the proof furnished by this laboratory of the etiologic connection of *Bacillus necrophorus* with foot-rot in sheep. The morphologic and biologic characters have been quite thoroughly worked out by Bang, Schmorl, and Ernst.

MORPHOLOGY.

Bacillus necrophorus is essentially a pleomorphic organism. It varies, according to nutrient soil and age of culture, from coccoid forms to filaments over 100μ in length and from 0.75 to 1.5μ in width. The longer forms appear as slender, undulating, beaded filaments. Generally, in the tissues these threads are matted together into an intricate network, like a mass of hair or even the more compact felt. The same appearance may be found in colonies. Frequently the filamentous forms present one wide or clubbed extremity, with the other extremity tapering. On the other hand, the older cultures—either animal tissues or artificial media—exhibit almost exclusively bacillary forms of various lengths, some so short as to be easily mistaken for cocci. Involution forms may be present in any culture, but certain media, notably that composed of a mixture of agar, gelatin, bouillon, peptone, and salt are particularly favorable to their development.

Motility.—Motion has not been observed in our experiments; in fact, it has been reported by Schmorl only. He examined the pleural exudate in hanging drop. He says:

> The shorter bacillus-shaped forms are mostly motile; they travel slowly through the visual field with a serpentine, or crawling, motion, but generally come very quickly to rest. The longer threads are for the most part absolutely motionless; only in the entirely detached forms does one notice pendulous movements being slowly executed. The signs of motility can be demonstrated only when the material for observation has been taken from an animal just killed or just dead. If it has been dead a longer time, one finds rods and threads altogether in the resting condition, from which they can sometimes be aroused by making the observation on a warm stage in a vacuum. Most of the rather thin and pale threads possess a characteristically stiff appearance. They float along sometimes completely extended; at other times they exhibit slight winding motion. But very seldom does one find specimens which appear spirally twisted.

Over against this statement of Schmorl may be placed that of Ernst:[14]

> The merely feeble, oscillating, molecular movements of the rods and the pendulous, serpentine movement of long, undulating threads in changes of position, according to

the law of gravity, permit no positive decision as to motility. In order to examine the bacteria as to their motility I employed cultures; and since young, 36-hour, cultures in the hanging drop showed no active change of place beside the ordinary molecular motion, and furthermore, since in the employment of material from cultures whose growth was just becoming visible (24–36 hours), flagella were not demonstrated by mordants which gave good results in control experiments with edema and cadaver bacilli as well as colon forms, a denial of motility would appear perfectly just.

In this laboratory the examination for motility was made with fresh cultures and with tissue from animals within one hour after death, both by means of hanging drop and by the application of flagella stains. In no case was it possible to claim motion for these bacilli.

Staining.—The necrosis bacillus stains readily with the ordinary aniline dyes, Löffler's methylene blue, and Ziehl's carbol-fuchsin, producing particularly good effects. Alkaline toluidine blue (1 per cent solution), while not giving the brilliant effects of fuchsin, makes perhaps the best reagent for routine use. The slide, or cover slip, dipped in the stain, immediately washed in water and mounted, is a very rapid and satisfactory method of bringing out the beaded appearance of the organism. It does not stain by Gram.

In the study of fresh tissue smears, it is usually sufficient to make a film on a slide with a teased particle of the suspected tissue, and, after the usual preliminaries, stain with one of the ordinary dyes mentioned, preferably methylene blue or toluidine blue. Whenever it was desired to employ differential staining, we found the following procedure to answer all requirements: The stains are kept ready for use in wide-mouthed bottles. Prepare the film on the slide in the usual manner, fix in the flame, dip it from two to five seconds in a 1 per cent alkaline toluidine blue, wash it thoroughly in water, counterstain it in a 0.2 per cent Neisser's Vesuvian brown, wash it in water, dry, and then mount it in balsam.

An excellent method of double staining was devised for *Bacillus necrophorus* by Bang. Bits of the necrosed tissue were hardened in Müller's fluid, thoroughly washed, and further hardened in alcohol. (Alcohol alone he did not find suitable.) The sections are placed a few minutes in toluidin-safranin (produced like aniline-gentian violet), dehydrated by means of an alcoholic solution of safranin; after this, fluorescin clove oil, pure clove oil, alcohol, watery methyl green, alcohol, xylene, balsam. The bacilli are stained a beautiful red, while the tissue is stained green; no other investigated bacteria can stain in this manner.

Mention has been made of the beaded appearance of the *Bacillus necrophorus* in stained preparations. This is noticeable equally in tissue smears or sections and in films from cultures. The longer rods and threads particularly exhibit this characteristic. It is due to the occurrence in the filaments of unstained spaces which were at first thought to be spores. Spore-staining methods, however, do not alter them.

Careful study of this peculiarity reveals several phases of it. Sometimes a thread will be most regularly marked off into alternate sections of stained and unstained material; again, decided irregularity characterizes the arrangement—long vacuole-like inclusions alternating with shorter stained squares or bacillus-like spaces of stained material may alternate with shorter colorless portions; again, the vacuoles may appear like a chain of colorless rods lying on a ribbon of blue or whatever color may be used for the stain. Sometimes the stained material is so little in quantity that the thread seems like a string of spores, oval or rod shaped, with thin, deeply stained partitions between them. On the other hand, the filament presents itself as an unstained tube with a regular succession of deeply stained coccus-like granules much resembling streptococci, or these granules may be alternately arranged along the sides of the tube.

BIOLOGY.

Cultivation of the *Bacillus necrophorus* is not easy. It is an absolute anaerobe. Investigators differ concerning its requirements as to temperature. Nocard and Leclainche[53] give 30° to 40° C. as the limits of growth, with the optimum at 37° C.; Jensen adopts the same extremes, but places the optimum at 34° C.; whereas, according to Ernst, development occurs only between 36° and 40° C., and the optimum is 39°. Our own investigations have shown that 30° to 40° C. represent the extremes of temperature at which the ordinary work of the laboratory may be satisfactorily carried on; nevertheless, we have on different occasions been able at 28° C. to grow in agar-bouillon shakes typical colonies, which responded to the usual tests of morphology, odor, and pathogenesis. With us the optimum was 35° C.

The usual culture media of the laboratory are either unsatisfactory or altogether inimical to the development of the necrosis bacillus. Agar-agar was often employed with only passable results, but more satisfaction was obtained from the following combinations: Agar-bouillon (A–B); agar-gelatin (A–G); serum-agar (S–A); serum-agar-gelatin (S–A–G); and two suggested by Ernst—1.5 per cent agar in a peptone-salt-bouillon (A–B–P–S) and 0.7 per cent agar and 7 per cent gelatin in bouillon with 5 per cent peptone and 2.5 per cent salt (A–G–B–P–S). The first four mixtures were usually prepared in the proportions of equal parts, although other proportions were adopted for the purpose of varying the consistence of the medium. Fluid blood serum, milk, rabbit bouillon, and Martin's bouillon were also employed.

PLATE CULTURES.

Bouillon agar.—Great difficulty was experienced in getting the organism to develop colonies in Petri dishes. Numerous attempts were made by displacing air with hydrogen in a hydrogen jar, and by

the formation of a vacuum by withdrawing the air under a bell jar by means of a vacuum pump, but success was not attained in any instance. Recently it was endeavored to grow the organism in Petri dishes placed in a closed jar containing a solution of pyrogallic acid rendered alkaline by sodium hydrate. This method, which permitted the presence of only the inert nitrogen gas, finally resulted in characteristic colonies occurring throughout the medium with the formation of numerous gas bubbles. Several of these colonies in the dish of the second dilution (pl. 5, fig. 2) grew so close to the surface that some filaments extended to the upper stratum, and could be removed by means of a platinum needle. In about forty-eight hours after exposing the plates to this method, small, pinhead-sized, dirty-white, opaque, round colonies, possessing no distinctive features, were visible to the unaided eye below the surface. Many small round or oval gas bubbles could also be observed. By means of a small magnifying glass these colonies were seen to possess a yellowish-brown center surrounded by a thin, light, almost translucent border, which, under the microscope, appeared floccose. After three days the colony presented to the naked eye a woolly appearance, and the microscope now revealed the central structure as a felted maze of threads and the floccose character of the border as long, wavy filaments.

SHAKE CULTURES.

Agar-bouillon.—In eighteen to twenty-four hours after inoculating a tube either from necrosed tissue or from a colony in another tube, or with a loopful from the depths of a pure Martin's bouillon culture,

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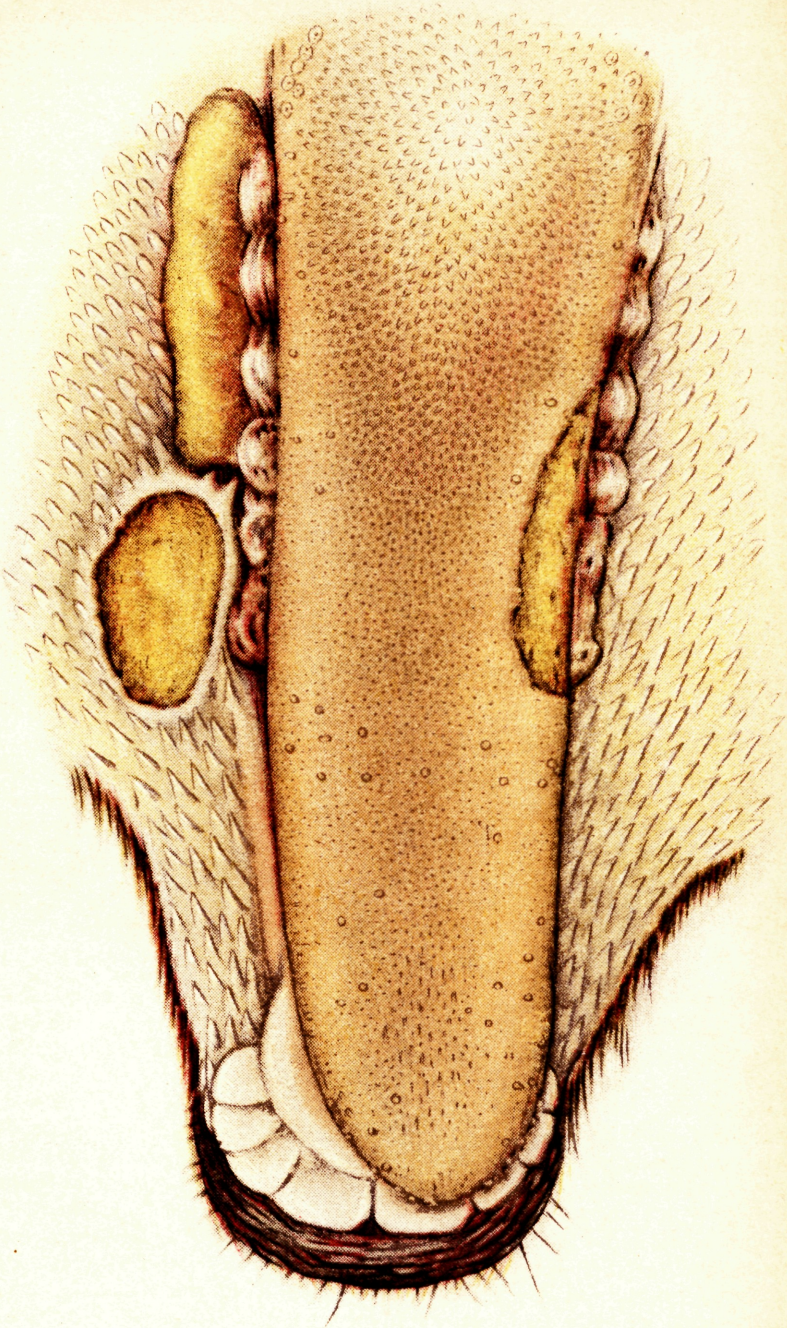
DESCRIPTION OF PLATE 1.

Tongue and cheek of calf showing lesions of necrotic stomatitis as a result of natural infection. Notice the zone of thickened granulated tissue surrounding the dry, cheesy, grayish-yellow areas of necrosis both in the tongue and cheek.

DESCRIPTION OF PLATE 2.

FIG. 1.—Section of the upper lip showing the necrosis bacilli in their special rôle of producing a deeply penetrating necrosis. The cuticular layer has suffered complete coagulation necrosis and caseation. The drawing depicts the bacilli in the act of carrying the necrosis down between the papillæ. Lodged in the interpapillary epithelium they have completely destroyed the portion where they lie and have exerted their toxic influence on the cells to the left. To the right is a section of a papilla whose suprapapillary layer of epithelium has been destroyed next the bacillary mass preparatory to the attack on the connective tissue framework of the papilla. Stained with methylene blue and eosin. Magnified about 640 diameters.

FIG. 2.—Section of liver of rabbit No. 1183, inoculated with an emulsion of necrosed tissue obtained from rabbit No. 1166, which had been inoculated with material from a pig affected with necrotic stomatitis. The periphereal area of caseation delimited by the well-defined line of demarcation is the result of the extension of the necrosis by contiguity of structure as the abdominal wall at this point was adherent to the capsule of Glisson by a plastic exudate. No other areas of necrosis were observed in the liver. Stained by hematoxylin and eosin, and magnified about 22 diameters.



NECROTIC STOMATITIS WITH LESIONS INVOLVING TONGUE AND CHEEK.

Haines del

A.B.GRAHAM CO. LITH. WASH.D.C.

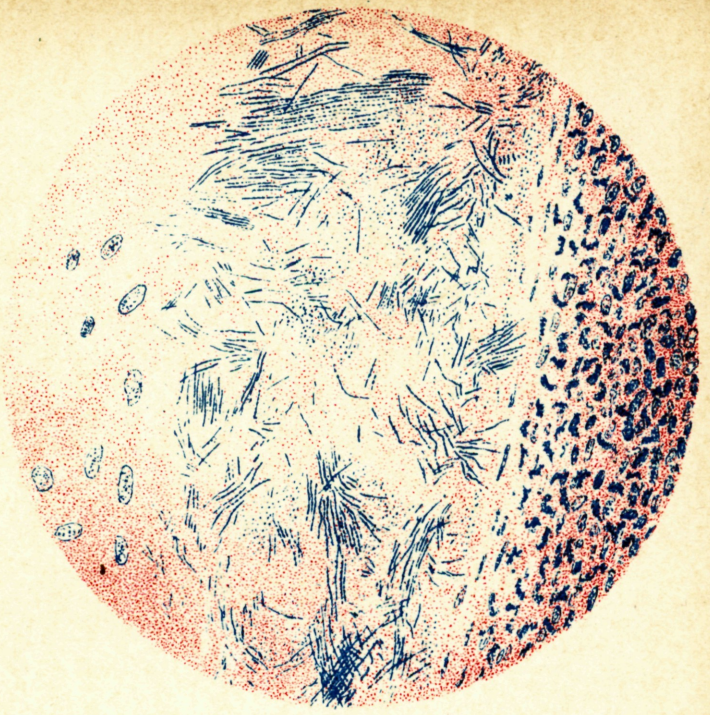


FIG. 1—SECTION OF UPPER LIP OF CALF SHOWING NECROSIS BACILLI.

FIG. 2.—SECTION OF LIVER OF RABBIT SHOWING A PERIPHERAL AREA OF CASEATION.

the tube is studded with small oval gas bubbles. At this time, also, rarely with the A–B medium, frequently with the softer forms, as S–A–G, A–G (2:1), A–B–P–S, and A–G–B–P–S, the column of culture medium will be transversely ruptured in one, two, or more places by the pressure of the gas. In forty-eight hours these sections will often be separated 2 to 5 mm. and even more from each other. We have sometimes seen this gas formation go on for the next two days, sufficiently strong to raise the upper portion of the medium 2 cm. The dilution from the above-described tube—tube 2—would often follow tube 1 quite closely in the quantity of gas bubbles formed, though not in the breaking up of the medium. Tubes 3 and 4 would usually show a great diminution in the quantity of gas bubbles and no breaking up of the medium.

In the development of the growth, our experience tallied quite closely in a few notable points with that of Ernst. For instance, shakes sown with necrosed material would often show, after thirty-six to forty-eight hours, a fine grayish white mist of cloudiness at the lower portion of the tube. In our experience, even with slight magnification, it was possible to detect no particular structure. A film made from this portion of the culture medium would always show beaded forms. Again, when the medium used was jelly-like in consistence, the unabsorbed gas, instead of remaining as bubbles at the point formed, would gradually float upward toward the surface. The original seat of these bubbles and the pathways along which they had risen would be coated with a fine bacterial growth. Thus would be formed numerous filmy ribbons, extending from near the surface down into the depths of the tube, where they would be anchored by a crescent-shaped body. The time and rate of growth and appearance of colonies in the tube are sufficiently stated in the above description of plates.

STAB CULTURES.

Agar-agar.—Near the close of the second day a few grayish-white colonies make their appearance at the bottom of the needle track. Gradually these increase from below upward to within 1–1.5 cm. of the top of the stab canal. Thus is formed a thin, narrow, opaque, yellowish or grayish white line of growth surrounded by a thin whitish cloud, which on slight magnification is seen to be composed of minute wavy threads.

Along the needle track, and, if the medium is not too hard when inoculated, throughout the culture may be seen numerous round and oval gas bubbles.

Serum-agar.—Time and height of bacterial growth and gas formation are like the preceding. At times the needle track is the center of a whitish film or merely a thin line of cloudiness of the medium;

again, the growth may be denser, similar to that described for agar-agar. The serum is never liquefied, although in very old cultures it will be natural that the zone of cloudiness referred to will have spread nearly to the walls of the tube.

Cultures in Fluid Media.

Bouillon.—The organism can be grown in ordinary peptonized beef broth, rabbit bouillon, and in Martin's broth, the maximum development occurring at the temperature of 35° C. in a hydrogen jar. The bouillon becomes turbid with the formation of some gas which is noticeable by the surface bubbles. Later the bacillary masses sink to the bottom in the form of whitish viscid flakes, causing the fluid to become clearer. The cultures have a peculiar odor, very characteristic, which will be referred to later. There is no film formation, but a tendency to develop a ring around the border of the medium has been observed. (See "Milk" and "Fluid serum," on next page.)

Action of Germicides.

In determining the germicidal power of disinfectants a measured volume of a forty-eight-hour bouillon culture of the necrosis bacillus was intimately mixed with an equal volume of the disinfecting solution, thereby reducing the strength of the germicide to one-half. Three platinum-wire loopfuls were then transferred to fresh rabbit bouillon tubes after varying periods of exposure. After an exposure of 1 minute in a 2 per cent solution of carbolic acid the bouillon tubes showed growth, but in the tube representing a two-minute exposure no development occurred. With bichloride of mercury an exposure of nine minutes to a $\frac{1}{2000}$ solution prevented growth. Formalin in the strength of $2\frac{1}{2}$ per cent solution (1 per cent formaldehyde) killed the organism in thirteen minutes.

Chemical Activities.

Pigment production.

Chromogenesis is wanting.

Odor production.

All cultures develop a substance or substances which evolve an odor well described by Ernst as between the odor of cheese and that of glue. The stench is so characteristic that the presence of the bacillus is recognized at once in the tissues of either natural or experimental infection as well as in cultures on artificial media.

Production of substances that liquefy.

Gelatin is not liquefied. The growth of the bacillus is likewise without effect on hardened blood serum.

INDOL FORMATION.

Indol is formed and may be demonstrated in three-days-old cultures made in Martin's bouillon.

PRODUCTION OF CURDLING FERMENTS.

Milk is not coagulated nor is acid produced. Fluid serum is coagulated.

PRODUCTION OF TOXINS.

That the necrosis bacillus produces a toxin is evidenced, not by the isolation of the same from artificial cultures, but by (1) the character of death in the disease, (2) the quality of the rigor mortis, and (3) the study of the pathologic histology.

The toxic character of death is not particularly noticed in animals suffering from stomatitis when inappetency and inability to take nourishment have produced an enfeebled condition. Nor, again, is it noticeable in those animals which die with embolic foci in liver or lungs, the symptoms arising from the diseased organs often masking the signs of intoxication. However, rabbits inoculated subcutaneously in the back will persist, without any other sign of the disease except the abscess, for about five or six days. Suddenly, on the sixth or seventh day, without any premonitory signs, the rabbit will be thrown into convulsions, coming out of one to lie with its head turned sideways and buried in the bottom of the cage until another attack, dying usually in a few hours after the first convulsion. Quite often in these cases the local lesions, not being very extensive, and not involving any important organ, will not be sufficient to produce death directly. Such a course as this points unmistakably to a toxinemia which has attacked the nervous system.

The limits of this article do not permit a discussion of the factors entering into the production of cadaveric rigidity. For our present purpose it is sufficient to call attention to the fact that the intensity and long duration of the rigor mortis observed in the experiment animals and described later in this paper comports perfectly with the well-known fact that the presence of toxins in the blood promotes muscular rigidity.

It may be stated with positiveness that *Bacillus necrophorus* does not enter an unimpaired tissue. Most, if not all, of its infections with which we are acquainted require for their inception a break in the continuity either of mucous membrane or skin. A histologic study of an affected area, elsewhere examined in greater detail, reveals a center of completely destroyed tissue marked by an entire absence of the specific bacteria in question. The boundary of this dead area is formed by great bundles of filaments of *Bacillus necrophorus*, large numbers of leucocytes, and a fair sprinkling of tissue cells whose nuclei still

respond to stains. The immediately adjoining border of surrounding healthy tissue is seen when carefully examined to possess numerous cells whose protoplasm has been more or less destroyed, and in among these dying cells a few scattered filaments have advanced like skirmishing parties before the main army. It is a true picture of a bacillary invasion of tissue begun by means of the noxious effects of a soluble toxin.

Thus far all attempts to recover the toxic substance either from cultures or the bacilli themselves have failed. From this, Jensen,[21] whose assistant, L. Bahr, has made the only experiments thus far recorded, assumes that either the necrosis bacillus forms these substances only in the living animal or they are of such volatile character that they are destroyed as quickly as they are formed.

IMMUNITY.

The literature of *Bacillus necrophorus* has contained no word on acquired immunity until the article by C. O. Jensen[31] referred to above. This eminent investigator and early worker with the necrosis bacillus states that his assistant, Bahr, has demonstrated by experiments not yet published that intravenous injections of cultures of the *Bacillus necrophorus* carefully given to goats protect them from quite large quantities of the same given subcutaneously. Jensen further states that Bahr has produced in the same manner an immunity in guinea pigs from intraperitoneal injections. In view of the fact that most investigators pronounce the guinea pig almost if not quite absolutely immune, the statement needs further elucidation. On the contrary, while we are not willing yet to build any hypothesis upon it, we find that our reinoculation experiments have given us the impression that susceptibility is increased thereby rather than diminished.

OCCURRENCE IN NATURE.

There is hardly room to doubt that the *Bacillus necrophorus* is a normal inhabitant of the healthy intestine of at least one species of our domestic animals—hogs—and possibly of the cow and horse. It is also found in the manure, and therefore in soil contaminated with the latter. Bang's[2] discovery of the association of the organism with the necrotic processes in the intestine in hog cholera, and also as cause of an intestinal diphtheritis in calves secondary to an intestinal catarrh[1] seemed to require the intestine as the normal habitat of the necrosis bacillus. Could this be demonstrated we should then have an explanation of the remarkably ubiquitous character of the organism as exhibited in the wide diversity of diseases caused by it. In this manner could be explained its relation not only to the necrotic inflammations occurring in the vagina and uterus, but also to all the external necrotic processes. This Bang succeeded in doing. He twice made inocula-

tions of the intestinal contents of healthy hogs with the result of demonstrating the presence of *Bacillus necrophorus*. An analogous investigation by him of the intestinal canal of a cow was not so successful.

Pathogenesis.

Very few organisms exhibit a wider range of pathogenesis. According to clinical observation the necrosis bacillus has so far been found pathogenic for cattle, sheep, goats, antelope, reindeer, red deer, roe deer, horses, monkeys, hogs, kangaroos, rabbits, dogs, guinea pigs, and chickens. Experimental work adds to the foregoing list mice and pigeons.[14]

It is probably safe to assert that no tissue of the body of a susceptible animal is safe from its destructive influence.

Under natural conditions.

Natural infections induced by *Bacillus necrophorus* may be considered as follows: Necroses of the skin, hoof, muscle, cartilage, mucous membranes (mouth and upper air passages, digestive tract, genital tract), navel, and viscera.

Necrosis of the skin in horses has occurred enzootically on a large breeding farm, the necrosis appearing on portions of the skin exposed to pressure of the harness. A necrotic form of scratches has also been shown to be a local infection of *Bacillus necrophorus*. Gangrenous pocks in cows have the same origin, and consist of an acute necrotic inflammation of the skin and soft parts of the teats. In hogs such a necrotic process has occurred in the skin of the muzzle, of the outside of the lips, of the feet, and, in sows, of the udder.

Necroses of the hoof include in horses a progressive necrosis of the soft parts of the hoof, often involving the bones and cartilages; in cows, reindeer, and roe deer, panaritium, or so-called foot-rot, involving tendon sheaths, tendons, bones, and joints; in sheep, foot-rot, recently shown to be due to the necrosis bacillus.

Necroses of muscle have been reported in connection with a granulating wound of the inner side of the hind leg of a cow, also as a result of the passage of a foreign body from the stomach into the heart muscle, and also in a case where a cow's heart, kidney, and some of the voluntary muscles were affected.

Necroses of cartilage are represented by those already included under hoof necrosis, by quittor, or fistula of the lateral cartilages, and by the laryngeal cartilages in many cases of necrotic stomatitis.

Necroses of bone have been reported in association with the hoof necrosis of various animals, in the vertebræ in the course of some cases of necrotic stomatitis, and in the turbinated bone of the horse.

Necroses of mucous membranes may be regarded as quite frequent. Those of the mouth and upper air passages are fully discussed in this

paper, and have been recognized in the calf, adult cattle, pigs, sheep, kangaroos, rabbits, monkeys, dogs, and chickens. No less sensitive are the mucous membranes of the digestive tract. In pigs the upper portion of the esophagus, by extension from the mouth, and in calves the esophagus in its entire length, have been affected. In hogs these "necrophorus" patches have been found in the stomach, small intestine, cecum, colon, and rectum. In horses they have been demonstrated in the colon; in cattle, in the rumen, in the reticulum, and in the small intestine; and in the deer and antelope, in the stomach.

The mucous membranes of the genital tract of cows that have recently calved are often invaded by the *Bacillus necrophorus*, resulting in a necrotic vaginitis and a necrotic metritis.

Navel disease in calves and lambs[65] is dependent in a considerable number of cases on infection of the wound by the necrosis bacillus.

Bacillary necroses of the heart, lungs, liver, kidney, and spleen, also of the udder, have all been reported as the result of metastasis from the original seat of the disease, in necrotic stomatitis, necrotic scratches, the various forms of foot-rot, and infection of the genital passage.

The classic example of *Bacillus necrophorus* in mixed infections is hog cholera. Here it has been proved unequivocally that the deep necroses and so-called diphtheric processes occurring in the body of a pig affected with hog cholera are due in some cases to the invasion of the necrosis bacillus. It has also been found as a secondary invader in the necrotic patches in so-called fowl diphtheria.

UNDER ARTIFICIAL CONDITIONS.

The pathogenicity of *Bacillus necrophorus* under artificial conditions was tested upon rabbits, mice, guinea pigs, chickens, pigeons, calves, sheep, and pigs, in order to establish its causal relation to the disease in question.

EXPERIMENTS ON RABBITS.

Subcutaneous method.—These animals are highly susceptible to the action of the *Bacillus necrophorus*, and to this susceptibility is due the ease with which the presence of the germ in diseased tissue may be demonstrated. A bit of tissue adjacent to the border of the necrosed area is emulsified in a normal saline solution. The subcutaneous inoculation of a rabbit with 0.5 c. c. of this emulsion will result in the death of the animal within one week. In order to free the tissues of the experiment animal from other forms of microorganisms naturally present in material taken from such an exposed place as the mouth, it is advisable to use a second or even a third rabbit. The first rabbit will, however, in spite of the contaminated material used in its inoculation, show very characteristic lesions,

which can be referred to the action of no organism other than the bacillus of necrosis. The chief of these typical changes will be noted at the point of inoculation, where, lying beneath the skin and extending down for a greater or less depth into the muscular tissues, is found an irregular area about 3 to 5 cm. in diameter. This area offers to the naked eye much the appearance of a flattened mass of soft, fresh putty, and to the nose the penetrating odor already referred to as between the smell of cheese and that of glue. This pulpy, yellowish white, malodorous mass is the detritus of muscular, fatty, and vascular tissues which have been attacked and destroyed through the presence of the necrosis bacillus as well as by its effective poisons. Reaching out into the surrounding tissues for about 4 cm. in all directions is found a zone of inflammatory tissue, and the subcutaneous and muscular tissues of the abdominal region are inflamed and edematous through extension by gravitation of the disease process from the local lesion caused by inoculation. Not seldom in these cases is there to be observed a marked development of gas bubbles. Frequently that portion of the large colon adjacent to the diseased abdominal wall is greatly injected and adherent to the parietal peritoneum by a plastic exudate containing numerous short and long forms of the bacillus of necrosis. This part of the peritoneum is also inflamed and presents petechial hemorrhages. Examination of the soft mass found in the necrosed area at the point of inoculation shows that it is penetrated in every direction by long thread-like bacilli, and the subcutaneous inoculation of a second rabbit with a small scraping from this mass serves to eliminate a large proportion of the contaminating organisms. Because of the greater purity of the material now used, the inoculation will not result fatally until a period usually from eight to fourteen days, although occasionally death has been prolonged until nineteen, and in one case twenty-three, days. In many instances it will be found that this longer period of time has proved sufficient to allow the circulation to take up a few of the bacilli and deposit them in the plexuses of the lungs, liver, or kidneys, where small, yellowish white spots of necrosis will result, which may be readily peeled out as if in a capsule. From these secondary visceral necroses, pure cultures of the *Bacillus necrophorus* may now be obtained, and its further development secured by the utilization of anaerobic methods of culture. The injection of 0.5 c. c. of these pure cultures under the skin of the back produced the same characteristic yellowish white area of muscular necrosis about the point of inoculation and the peculiar penetrating odor so constant with this bacillus. The course of the disease is about the same as when an emulsion of the fresh tissue has been injected, and, in those cases in which life was prolonged several weeks, metastatic areas of focal necrosis were always noted. The approach of death is usually indicated by convulsions; the animal

comes out of one to be seized with another, death generally resulting in a few hours after the onset of the first convulsion. In the majority of rabbits that succumbed to this disease, a marked rigor mortis was observed, especially noticeable in the hind quarters, causing the back to be arched and the legs contracted as if in a tetanic spasm. Microscopic examination of tissue taken from the necrosed area or from metastatic lesions of the liver or lungs shows the presence of typical necrosis bacilli in great numbers. In the case of organic lesions these filaments are seen to be arranged along the border of the area of necrosis, whereas the central portion is amorphous and does not reveal the presence of any microorganisms.

Intravenous method.—The intravenous method of inoculation was adopted in nine cases, four of which resulted in the death of the animal. Each rabbit received in the posterior auricular vein 0.3 c. c. of an emulsion of the tissue filtered through cotton, the filtrate containing numerous bacilli.

The course of the disease ranged from seven to twelve days. The symptoms exhibited in all cases were the same as those induced by subcutaneous inoculation and consisted of gradual emaciation followed by the loss of appetite and by convulsions, paralysis, and death. The postmortem examination showed the principal lesions to be located in the thoracic cavity. The lungs contained several caseous nodules the size of peas surrounded by a hemorrhagic zone, and in one rabbit the left principal lobe was adherent to the costal pleura by a thick, purulent exudate. In each case the costal pleura contained several metastatic foci and the chest muscles in two instances were the seat of

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DESCRIPTION OF PLATE 3.

Section of lung of rabbit No. 1197, inoculated subcutaneously with a bouillon culture of *Bacillus necrophorus*, showing four metastatic foci. Stained with Löffler's methylene blue. Magnified about 25 diameters.

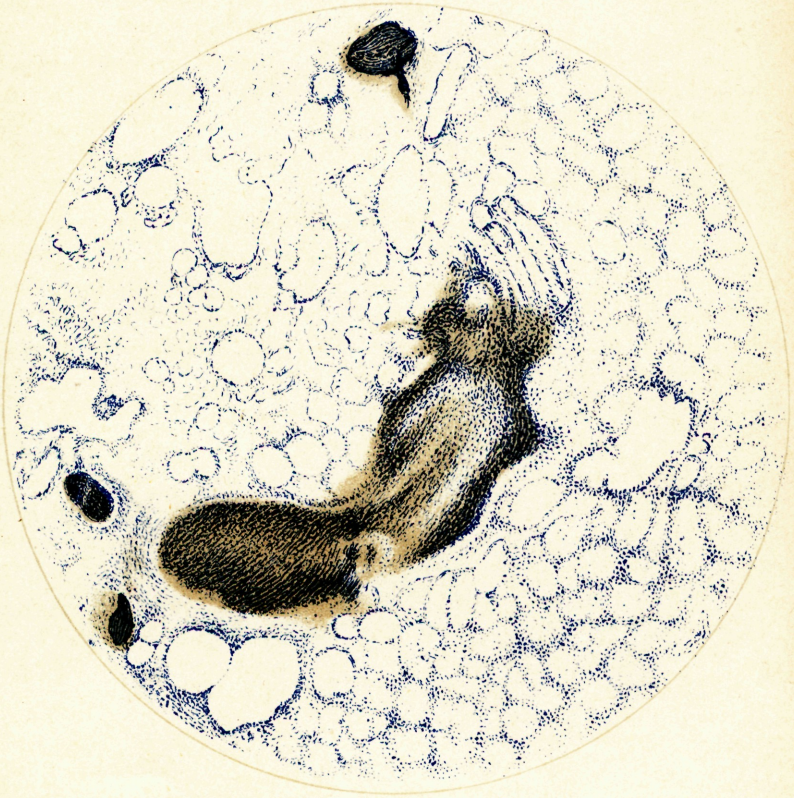
DESCRIPTION OF PLATE 4.

Section of lung of rabbit No. 1197, showing the superior focus in plate 3 greatly amplified. Notice the felted network of wavy filaments and smaller forms of *Bacillus necrophorus*. Stained with Löffler's methylene blue. Magnified about 450 diameters.

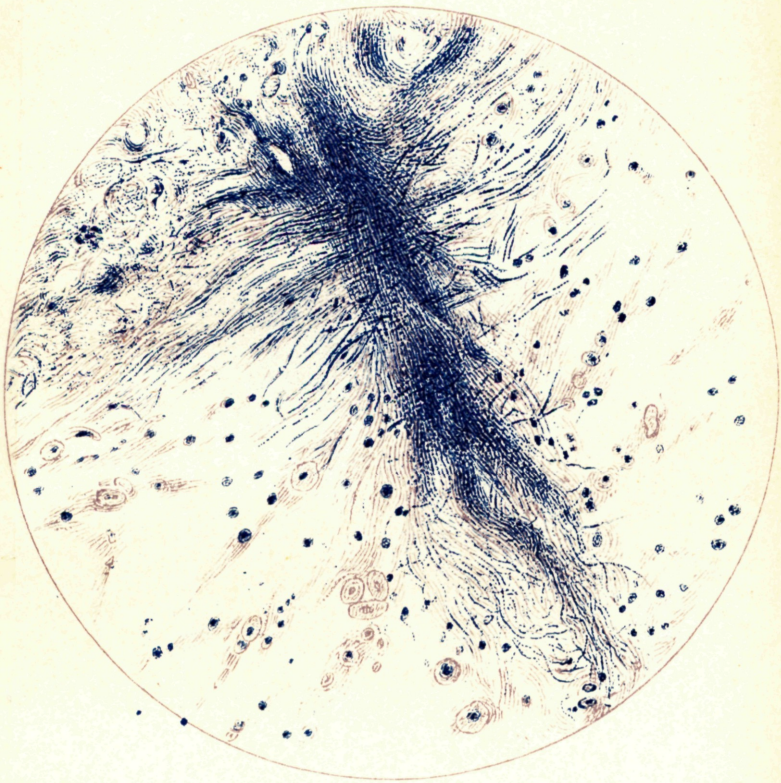
DESCRIPTION OF PLATE 5.

FIG. 1.—Cover-glass preparation from a metastatic focus in the wall of the left ventricle of rabbit No. 1219, which died on the fourteenth day following a subcutaneous injection of a Martin's bouillon culture of the necrosis bacillus. Stained with Ziehl's carbol-fuchsin. Composite drawing made with camera lucida at base of stand with Zeiss No. 6 compensating ocular, 2 mm. oil immersion objective and 160 mm. tube length.

FIG. 2.—Photograph of Petri dish containing numerous characteristic colonies of necrosis bacilli forty-eight hours after their inoculation into bouillon agar and following their incubation at 39° C. in a closed jar containing pyrogallic acid. Notice the gas formation and the fluffy outlines of the colonies, with their dark dense centers.



SECTION OF LUNG OF RABBIT SHOWING METASTATIC FOCI.



SECTION OF LUNG OF RABBIT SHOWING FELTED NETWORK OF BACILLUS NECROPHORUS.

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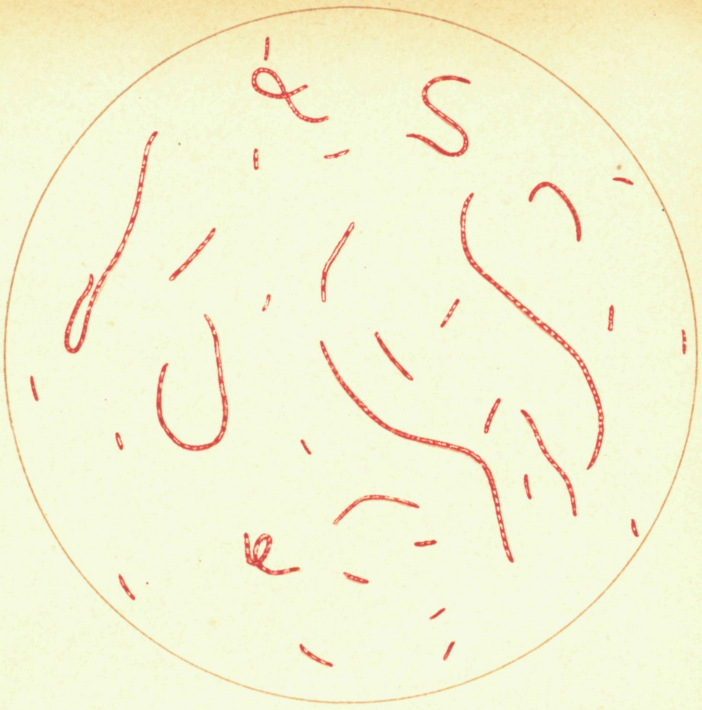

FIG. 1.—BACILLUS NECROPHORUS FROM METASTATIC FOCUS IN RABBIT'S HEART.

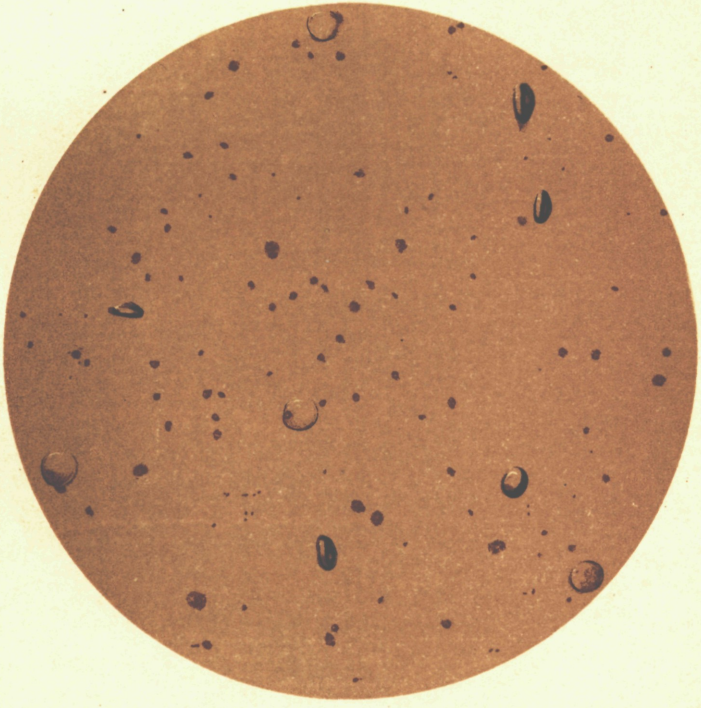

FIG. 2.—PETRI DISH CONTAINING CHARACTERISTIC COLONIES OF NECROSIS BACILLI. X 2.

one or two localized areas of coagulation necrosis. In another the caseous process had included the entire surface of both lungs, the pericardium, and the heart itself until all were superficially fused into one cheesy mass. The liver of one animal contained eight superficial areas of caseation varying in size from a pea to a hazelnut and was adherent to the diaphragm and abdominal muscles. All other organs were normal. No lesion was observed about the point of inoculation in three cases; the fourth showed a narrow strip of necrosis along the line of the vein for about half an inch. Cover-glass preparations made from the lesions contained numerous characteristic specimens of *Bacillus necrophorus.*[a]

EXPERIMENTS ON MICE.

Subcutaneous inoculation.—The remarkable susceptibility of a white mouse to "necrophorus infection" makes this animal an excellent medium for the preservation of the virulence of that microorganism, as well as a means of obtaining it in pure culture. Unfortunately, this animal's extreme susceptibility to many forms of the bacterial flora of the mouth disqualifies it for use in the early stages of an investigation. The inoculation experiments may be carried on by placing a small bit of necrosed tissue into a pocket in the skin of the back, or by injecting into the same region 0.1 c. c. of a fluid culture or emulsion containing the germ in a pure state. In two to four days the point of inoculation is covered with a rather thick, blackish, or dark-brown dry scab around which is a zone of redness. Beneath this scab proceeds a coagulation necrosis spreading through the subcutaneous tissues until the mouse is completely mummified, shriveled up, and covered with a dry parchment-like coating; or, penetrating into the body cavities in its course, successively caseates muscle, cartilage, bone, and viscera. In some of these cases so general becomes the caseous process that it is difficult to decide whether the viscera have suffered embolic necrosis or have become involved in the progressive caseation through extension by contiguity. In cases in which necrotic action was less widespread, small focal necroses containing the *Bacillus necrophorus* in pure culture were found in the lungs, liver, and spleen. In our experiments mice have died as early as five, and as late as twenty-one days.

[a] While these pages were in press an interesting experiment in natural infection was completed. Rabbit 1262 died, presenting a complete picture of Schmorl's disease. It had been associated with an inoculated rabbit affected with a "necrophorus" ulcer on the right ear, and was repeatedly noticed licking this sore spot. The necropsy revealed a necrotic stomatitis involving the gums, dental alveoli, body of the inferior maxillary, floor of the mouth, sublingual and submaxillary glands, and the tissues of the face and neck. There were no internal necroses. Cover-slip preparations and inoculations, both artificial and animal, demonstrated the presence of *Bacillus necrophorus.*

EXPERIMENTS ON GUINEA PIGS.

Guinea pigs were inoculated with pure cultures of necrosis bacilli by both the subcutaneous and intraabdominal methods, but these were followed by negative results. Nine animals were used in the experiments, and doses ranging from 0.25 to 1 c.c. of a forty-eight-hour bouillon culture were injected without producing any unfavorable effects. However, one positive result was obtained with guinea pig No. 3181, which was injected intraabdominally with 0.5 c.c. of an emulsion of the necrosed tissue taken from the mouth of calf No. 3. Death followed on the tenth day. On autopsy the carcass appeared emaciated. The point of inoculation in the prepubic region was surrounded by an abscess several millimeters in diameter containing a rich yellowish pus. In the linea alba several inches above this abscess was a metastatic nodule 1.5 cm. in diameter, involving the muscular tissue and the peritoneal lining. It contained the same character of pus. On the right side of the linea alba the peritoneum was adherent to the contiguous loop of the colon opposite the last rib. The right and left lobes of the liver were almost fused into one by abscess formation. The right lobe particularly was the seat of several abscesses 1½ cm. long by 1 cm. wide, with a line of demarcation plain and straight between the part absolutely necrosed and the invaded portion. The spleen appeared mottled and slightly enlarged, and the kidneys were deeply congested. The lungs were engorged on the right side and showed one or two foci of hepatization. The presence of *Bacillus necrophorus* in the liver abscesses was demonstrated by microscopic preparations and by animal inoculations.

EXPERIMENTS ON CHICKENS.

Four fowls were injected—two by intravenous and two by intramuscular inoculations—with 0.75 c.c. of a forty-eight-hour Martin's bouillon culture, but in no case was the result fatal. Nothing was observed that would indicate that the birds had been injected, and after a period of two months they were chloroformed. The postmortem examination revealed absolutely healthy birds.

EXPERIMENTS ON PIGEONS.

The inoculation of two pigeons indicated that the bacillus is not pathogenic for these birds. One pigeon was inoculated intravenously with 0.3 c.c. of a forty-eight-hour culture in Martin's bouillon, the other bird with 0.5 c.c. of a similar culture into the pectoral muscles. This experiment was concluded six weeks after its inauguration by chloroforming the pigeons, but in neither case was any abnormal condition apparent.

EXPERIMENTS ON CALVES.

Subcutaneous inoculations.—Heifer calf No. 351, 7 months old, was injected October 5, 1904, on the inside of the upper lip with 1 c.c.

of an emulsion prepared from the point of inoculation of rabbit No. 1215, which was the seventh in a series of animals inoculated with the material from a calf affected with necrotic stomatitis.

October 7.—There is a slight reddening about the site of injection, with a temperature of 102.6° F.

October 10.—The temperature has reached 103.2° F., and a large tumor with a soft center is observed at the point of inoculation. Pus can be seen oozing from the opening made in the lip by the needle.

October 11.—There is an enlargement about 1 by 2 by 1 inch in size at seat of injection, with an ulcerating surface surrounding the point of puncture.

October 12.—The caseous nodule is about the same size, and is still suppurating.

October 14.—The enlargement on lip does not appear to have increased any in size. An opening simulating a rodent ulcer about one-half inch in diameter has formed on the inner side of lip which leads to the pus cavity in the center of the necrotic area. Thick creamy yellow pus issues from it.

October 17.—The pus has been evacuated from the abscess in lip, and the lesion has begun to heal.

October 18.—The lesion in the mouth is healing rapidly, and the animal has been removed from the experiment.

On August 14, 1904, a fragment of necrosed tissue about one-half the size of a pea was inserted into a pocket made beneath the mucous membrane on the right side of upper lip of calf No. 318, 4 months old. The tissue was taken from the seat of injection of rabbit No. 822, the second in a series of rabbits inoculated with a pure culture of the *Bacillus necrophorus* obtained from the lip of a Berkshire shoat affected with necrotic stomatitis.

August 15.—Temperature of the calf is 103.2° F., and an inflammatory zone is noticed about the punctured mucous membrane.

August 17.—At the seat of inoculation there is a hard spheroidal enlargement about 1 inch in diameter.

August 18.—The abscess at point of inoculation has not increased any in size. A plug of pus and necrotic material of one-half cubic inch in volume has been extruded from the caseous nodule in the mucous membrane at the seat of injection.

August 19.—A small quantity of very thick pus is being secreted from the abscess. Temperature remains about the same as on previous days, 103° F.

August 22.—Only a small ulcer with a slight reddening at seat of inoculation remains. Temperature 104.8° F.

August 24.—Lesion is healing; appetite is good; temperature 104° F.

September 1.—The ulcer at seat of inoculation has about healed. Temperature 102.4° F.

September 12.—Animal removed from this experiment.

Roan calf No. 350, 2 months old, was inoculated May 24, 1904, on the lower portion of the left cheek with tissue taken from rabbit No. 1015, which was one of a series of rabbits injected with the necrosis bacillus obtained from a case of foot-rot in sheep.

May 26.—There is a reddening of the mucous membrane about the seat of injection.

May 27.—The animal appears dull and languid and eats sparingly. The mucous membrane is of a grayish color and presents an ulcer about 1½ inches in diameter.

May 28.—A distinct and characteristic ulcer has formed, containing a caseous necrotic center surrounded by a zone of inflammation. From the caseous material scraped from the deeper portion of this ulcer rabbit No. 1117 was injected under the skin of the back. (This rabbit succumbed on the sixth day following, with characteristic lesions, from which the *Bacillus necrophorus* was obtained.)

May 31.—Point of inoculation in cheek of calf still shows ulceration, but swelling and inflammation are disappearing.

June 11.—Healing is about completed, there being only a small, depressed ulcer remaining.

Subcutaneous and intravenous inoculation.—On November 27, 1903, calf No. 337, 11 months old, was injected on the left side of tongue with 1 c.c. and inoculated in the right jugular vein with 5 c.c. of a culture of *Bacillus necrophorus* obtained from necrotic stomatitis of calves.

December 3.—The animal has remained perfectly well in every respect. No lesions.

December 16.—The calf to all appearances continues well.

December 26.—General condition remains good. Temperature has been normal throughout the experiment.

Owing to the negative result of this experiment it may be concluded that the animal in question was not susceptible to the injections, probably on account of its age.

Intravenous inoculations.—Gray calf, No. 359, was injected intravenously (right jugular vein) with 10 c. c. of a culture of the *Bacillus necrophorus* obtained from necrotic stomatitis of calves.

November 23.—The only reaction shown from the injection yesterday is the temperature of 103° F.

November 24.—The temperature reaches 106.8° F. The calf is now very sick, walks with a staggering gait, and hock joints are flexed much more than normal. It trembles, and eats scarcely anything.

November 25.—The animal shows about the same symptoms as yesterday, but more marked; pulse, 104.

November 26.—It is considerably weaker than on November 25, and has difficulty in getting on its feet. Temperature, 107° F.

November 28.—The condition is about the same; very weak, but can stand up; spiritless and refuses food.

November 29.—The calf seems somewhat weaker and walks with a staggering gait. Temperature, 104.6° F.

November 30.—It is still very weak and more stupid than yesterday; appetite is much improved. Temperature, 104° F.

December 1.—It shows no improvement in general appearance, but has a much better appetite.

December 2.—The condition is same as yesterday. Animal killed by bleeding.

The postmortem examination held shortly after death showed the carcass to be in a rather poor condition and the hair and skin dry and harsh. On opening the thoracic cavity the lungs were found to contain a number of encapsulated caseous nodules scattered quite regularly in the peripheral and superficial portions of the lobes. There were nine such areas in the right lung and seven in the left lung. Four of these nodules were surrounded by hemorrhagic zones, while

the remainder bore a striking resemblance to the early pulmonary lesions of caseous lymphadenitis of sheep, and were circumscribed by normal lung tissue. On sectioning they were seen to contain a yellowish white, thick, rather dry mass, from which the necrosis bacillus was obtained in purity. The liver showed three small superficial foci of necrosis the size of a grain of wheat, while the heart, spleen, and kidneys were apparently without lesions. No alteration of any kind was observed at the point where the intravenous injection was made. Culture media were inoculated with the caseous material from the necrotic areas in the lungs, and a rabbit was injected subcutaneously with similar material, with the result that characteristic development in the former case occurred within forty-eight hours, and in the latter case death of the rabbit followed on the eighth day with typical postmortem lesions.

EXPERIMENTS ON SHEEP.

Subcutaneous inoculations.—On August 22, 1904, a small fragment of necrotic tissue, obtained from the same source as that used on calf No. 318, was introduced into a pocket made under the mucous membrane of the right cheek of sheep No. 23, about 1 year old.

August 24.—At the seat of inoculation in the mouth there is an inflammatory process which has caused a small patch of necrosis in the mucous membrane. Temperature 104° F.

August 26.—The ulcerous area in the mouth has reached one-half inch in diameter and is secreting pus. The inflammation and swelling are somewhat reduced. Temperature 103.6° F.

August 30.—The lesion at the point of injection is decreasing in size and the temperature of the animal is 102.4° F.

September 1.—The ulcer has nearly healed. Temperature 102° F.

September 9.—No lesion at seat of inoculation. Condition of animal is good.

Sheep No. 102, pure Merino, born in the fall of 1902, was inoculated May 9, 1903, on the lower lip with a culture of necrosis bacillus obtained from necrotic stomatitis of calves.

May 21.—No symptom of the disease has thus far appeared.

June 1.—No lesions are to be seen in the mouth, and the sheep seems to be well and gaining flesh.

June 5.—Animal is removed from experiment.

EXPERIMENTS ON PIGS.

Subcutaneous inoculation.—On October 5, 1904, pig No. 1448, weighing 50 pounds, was injected inside of upper lip on the right side with 1 c.c. of the emulsion obtained from the same source as that used on calf No. 351. Following the injection the pig continued in good condition, and no alterations were observed at point of inoculation until October 12, when a small inflamed swelling was detected, which showed a small necrotic center. By October 14 this enlargement had reached the size of a hazelnut, with a small ulcerative surface about 5 cm. in

diameter. The lesion remained stationary for several days, when healing started, and by November 2 the ulcer had almost disappeared. On November 12 the animal was in good condition, without any alteration at seat of injection.

PATHOLOGY.

The pathologic process which everywhere characterizes *Bacillus necrophorus* is a necrobiosis, involving coagulation necrosis with subsequent caseation, and marked by a progressive invasion of the surrounding (particularly the deeper) tissue and a remarkable tendency to metastasis. When this process is applied to a mucous membrane we have presented to us a diphtheric inflammation plus caseation.

A discussion of terms at this point is necessary for clearness of definition. The Greek διφθερα=diphthera, means membrane. According to usage in medical nomenclature "diphtheritis" should mean an inflammation of a membrane. It is unfortunate that this term, seldom used in English—more frequently used on the Continent—has been made synonymous with diphtheria. This latter term is used to-day to refer solely to that disease process evoked by the presence and activities in the tissues of the Klebs-Löffler bacillus. That process is characterized usually, if not quite always, by the production of a false membrane. At the time of the application of this term, and for years afterwards, it was supposed that etiologically, this process of inflammation characterized by membrane formation was always the same. Bacteriology has exploded this idea, and it is now known that this process can be provoked by numerous causes other than the Klebs-Löffler bacillus. We see no difficulty whatever in thus limiting the term diphtheria as above.

The adjective "diphtheritic" very naturally and properly associates itself with "diphtheritis." Hence, so long as diphtheritis and diphtheria are used synonymously so long will diphtheritic be associated with diphtheria as the qualifying adjective. So we find that among most writers a diphtheritic inflammation is an inflammation excited by the Klebs-Löffler organism.[1]

A "diphtheric" inflammation, however, is an inflammation characterized by the formation of a διφθερα, or membrane. It is not synonymous with diphtheria, and may be induced by a variety of causes—mechanic, chemic, and microbic—other than Klebs-Löffler bacillus.

The name "calf diphtheria" is therefore incorrect when applied to necrotic stomatitis. The application of the adjective "diphtheric" is almost as misleading, since it stops short of a complete pathologic anatomy of the disease.

The principal lesions in necrotic stomatitis occur in the mucous membrane of the mouth and pharynx. The alterations may extend to the nasal cavities, larynx, trachea, sublingual lymph glands, lung, esophagus, intestines, and hoof. The oral surfaces affected are, in the order of frequency, tongue, cheeks, hard palate, gums, and lips. In the majority of cases the primary infection appears to take place in the tongue. The manner of infection in very young animals is connected, beyond all doubt, with the eruption of the first temporary teeth after birth or, in animals somewhat older, an inoculation which probably occurs most frequently by a sharp-pointed particle of food penetrating the mucous membrane. At the point of entrance the

system recognizes the presence and multiplication of the bacilli by a reaction marked by congestion and reddening, followed by an exudation rich in albuminoids or fibrin-forming substances, and a defensive immigration of leucocytes.

The metabolic products of the bacilli are exceedingly poisonous, killing everything with which they come in contact. Hence, the first effect of the organism is a necrosis, or death, of the superficial layer of epithelial cells and leucocytes at the seat of invasion. The cells either suffer fragmentation of their nuclei or become transformed into irregular flaky masses—the so-called hyaline masses. This constitutes superficial erosion of the mucous membrane. The process never stops here, though we may often recognize this stage in numerous recent foci of necrosis in a rapidly spreading form of the disease.

The second alteration is the production of false membrane by a combination of coincident changes. On the one hand, the necrosed epithelial cells and leucocytes, having lost their nuclei and finer structure, are deprived of their normal granulation and striation and take on a scaly appearance, being converted into hyaline substance; on the other hand, the albuminous exudate in which these dead cells are bathed precipitates fibrin or coagulates into fine threads. This is known as coagulation necrosis. The false membrane, then, is the result of coagulation necrosis of the inflammatory exudate and the entanglement in its meshes of the hyaline degenerated epithelial cells and leucocytes. This gives a grayish compact mass, more or less adherent to the underlying tissue which, by failure of the dead cells to be thrown off, may be built up an eighth of an inch or so.

The third alteration connected with this process is due to an invasion of the deeper tissues. The bacilli are always found on the border line between the living and dead tissue. Here, in great bundles of beaded filaments, they may be seen attacking the healthy tissue, which in turn has erected against the attack a wall of leucocytes, while masses of micrococci, tangles of streptococci, and clumps of bacteria are lodged in the superficial layers (pl. 2, fig. 1). Thus the process is carried down into the stroma or connective-tissue framework, and by the death of these deeper tissues are formed ulcers of varying depth. These may be sharply circumscribed, or at times diffuse, with thickened, slightly reddened borders surmounted by several layers of this necrosed tissue. The floor of the ulcer is formed by a grayish-yellow corroded surface, under which the tissue is transformed into a dry, friable or firm cheesy mass. In the tongue caseation may progress to two fingers' thickness into the muscular portion; in the cheek it may form an external opening permitting fluids to escape from the mouth; upon the palate it frequently reaches and includes the bone in its destructive course; upon the gums it has produced necrosis of the alveolar processes, causing loss of the teeth. By the coagulation necrosis occurring

in the region of the blood vessels, they become obstructed by pressure or sometimes by thrombosis, and thus the dead tissue becomes avascular, and the necrotic mass undergoes pulverization into finer and minuter particles until it is a dry, crumbly, yellowish mass of tissue detritus resembling cheese.

Symptoms.

Necrotic stomatitis is both a local and a systemic affection. Primarily it is local. The local lesion is the caseonecrotic patch or ulcer, developed as a result of the multiplication of the bacilli at the point of inoculation. The general affection is an intoxication or poisoning of the whole system, produced by a soluble toxin elaborated by the bacilli.

The stage of incubation is from three to five days. Calves have shown signs of the disease when only three days old. During this stage the animal organism is passive and manifests no symptoms. The stage of invasion is twofold—local reaction against the invading organisms and constitutional manifestations of intoxication. The first symptoms noted are disinclination to take nourishment and some drooling from the mouth. An examination of the mouth at this time may show on the mucous membrane of the tongue, hard palate, cheeks, gums, lips, or fauces a circumscribed area of infiltration and redness, possibly an erosion. The latter gradually extends in size and depth, forming a sharply circumscribed or at times a diffuse area of ulceration (pl. 1). It may measure anywhere from the size of a 5-cent nickel piece to that of a silver dollar or even larger. It has the appearance of a corroded surface, under which the mucous membrane or lingual tissue seems transformed into a dry, finely granular, or firm cloddy mass. It is grayish yellow in color, and is bordered by a zone of thickened tissue, slightly reddened and somewhat granulated. The necrotic tissue is very adherent and can be only partially peeled off. It is homogeneous, cheesy, and may extend to the depth of one inch into the underlying tissue, involving the muscular tissue or even the bones. The general symptoms are languor, weakness, and slight fever. In spite of plenty of good food, the calf is seen to be failing. It stops sucking, or, if older than a suckling, altogether refuses to eat. The temperature at this time may be from 104° to 107° F. The slobber becomes profuse, swallowing very difficult, opening of the mouth quite painful, and a most offensive odor is exhaled. The tongue is swollen and its motion greatly impaired. Sometimes the mouth is kept open, permitting the tumefied tongue to protrude. One or more of the above symptoms direct the attention to the mouth as the seat of disease; or, having noticed the debility and disinclination to eat, an examination of the animal may show a lump under the neck or swelling of the

throat or face as a result of the large partially chewed boluses of food that have collected there.

The following extract from a letter is characteristic:

> I noticed my calves beginning to fail about the first week in December, but could not account for it, as they were getting plenty of grain and hay. My attention was first attracted by a swelling under the neck of one of the calves. I cast the animal and found it was food that had collected and the animal couldn't swallow it. I removed the food, and in so doing noticed a large ulcer on the tongue and a very offensive odor. This was the first knowledge I had of anything being wrong with the cal es' mouths. They may have been sick for sometime before this.

Out of a herd of 100 belonging to this man, 70 were affected, and the letter emphasizes the insidious character of the onset.

The general affection at this time manifests itself by dejectedness, extreme weakness and emaciation, constant lying down, with stiffness and marked difficulty in standing.

The disease frequently extends to the nasal cavities, producing a thin yellowish or greenish yellow sticky discharge which adheres closely to the borders of the nostrils. Their edges also show caseous patches similar to those in the mouth. Sometimes the nasal passage is obstructed by great masses of the necrosed exudate, thus causing extreme difficulty in breathing. When the caseous process involves the larynx and trachea, there result cough, wheezing, and dyspnea, together with a yellowish mucopurulent saliva. When life is prolonged three or four weeks, caseous foci may be established in the lung, giving rise to all the signs of a broncho-pneumonia. Many of these cases are associated with a fibrinous pleurisy. The invasion of the gastrointestinal tract is announced by diarrheic symptoms.

In pigs the symptoms are practically the same as have been described for calves, although the tongue is not so likely to be involved. The mouth becomes necrosed in patches, especially in the region of the front teeth and tusks. Suppuration and destruction of tissue around the teeth may be so great that they finally become loosened and fall out. The jaws are swollen and the lips show cracks and scabs. The snout is frequently involved, resulting in some cases in necrosis of the end of the nose. The disagreeable odor exhaled from the mouth and the tendency of the affection to spread to the larynx, pharynx, and tonsils, and the mucous membrane of the stomach and intestines are greater with pigs than with calves. When the intestines become involved, a black offensive diarrhea is manifested, the pigs are dull, refuse to suckle, and are inclined to remain recumbent. Prostration and emaciation are especially marked when the digestive and respiratory organs are involved.

Course and Termination.

In the very acute form of the disease many of the cases run their course in five to eight days. In these the local lesions are not strongly marked, and death seems due to an acute intoxication. In other enzootics the majority of the affected animals live from three to five weeks. These are the cases that usually present the pulmonary and intestinal symptoms, and sometimes develop, in the case of bovines, caseonecrotic lesions of the liver.

Infective Character.

The consideration of this aspect of the disease involves a study of its infectiveness for animals and also the question of its transmissibility to man. Under the former must be considered the infection of an isolated case or the initial infection of a group of cases, the transmission of the disease from animal to animal of the same variety or species, and its transmission from animals of one species to those of another.

Necrotic stomatitis is enzootic—never epizootic; that is to say, instead of covering a wide area, like foot-and-mouth disease or pleuropneumonia in their march of devastation, it involves in its infection only the members of a few herds or the animals on a single farm. This is due largely to the nature of the infective agent. Being a strict anaerobe and not very resistant to germicidal influences, such as light, there is, under what are termed natural conditions, little possibility of the conveyance of the microbe from place to place. Another characteristic of the *Bacillus necrophorus* is that it is, strictly speaking, a secondary invader. This requires special conditions of receptivity on the part of the animal infected. For example, there must be a break in the continuity of the tissue to which the necrosis bacillus is applied.

It should be stated here that the *Bacillus necrophorus* is not to be regarded as a saprophytic guest of the intestines of hogs and herbivora which, under certain conditions, develops pathogenic properties. It is always and everywhere the producer of a progressive tissue necrosis characterized by caseous degeneration. Whether in or out of the intestine, whether in manure on the stable floor, or buried deep in the tissues of a susceptible animal, it always possesses this pathogenic property. But in the lumen of the intestine, possessing an intact epithelial lining, the necrosis bacillus is, for the time being, without effect. However, let this epithelium be injured by a foreign body, by corrosive fluids, by the action, for instance, of the hog cholera bacillus, and at once an entrance into the intestinal wall is afforded the necrosis bacillus, with the result that there develop diarrhea and caseonecrotic patches in the intestines. This relationship of the intact epithelial covering to bacteria normally present in the intestine was well

brought out in Jensen's experiments on calves with reference to white scours.

As to the infection of a single calf or pig or the initial infection of a herd, it is evident that, inasmuch as the *Bacillus necrophorus* is a normal inhabitant of the intestine of healthy hogs and presumably of cattle, the manure may be looked upon as the chief agent in transmission. Hence a most common method of infection in the calf or pig, when the gums are abraded or torn in connection with the eruption of the teeth, is suckling a cow or sow whose teats are filthy with manure. Again, the animal munching a little hay or straw which has been contaminated with manure may receive a stab at some point of the mucous membrane of the mouth by which the necrosis bacillus is introduced into the tissues.

The transfer of the disease from one animal to another occurs time after time when newly born animals are placed successively in a pen previously occupied by an animal that had contracted the disease. In this connection it must be remarked that the question is not alone that of the transmission of the disease of necrotic stomatitis, but of the transfer from one animal to another of the infective agent. In whatever part of the animal body the *Bacillus necrophorus* may have instituted the caseonecrotic inflammation which characterizes its pathogenic rôle, by whatever name the disease process may be called, be it foot-rot, necrotic quittor, necrotic scratches, necrotic vaginitis, or metritis or necrotic stomatitis, there we find a hotbed of infection and the certain groundwork of an enzootic. Hence the occupancy of the calving stall by a cow affected with panaritium or by a cow suffering with a vaginitis dependent upon this bacillus is sufficient to insure the development of a series of cases of necrotic stomatitis. The same principle is involved in the dissemination of the disease through one or more litters of pigs. The very first investigator in this line made the experiment of placing a healthy calf in a stall with two calves affected with the disease. The third calf came down in five days with the same malady. The author considered the calves' habit of licking one another as being chargeable with the transmission of the disease. Blažeković[5] also reports an unintentional experiment of the same sort. The exposed calf began to cough in three or four days, after which the necrotic patches were visible in its mouth. It is also recognized that the practice of feeding calves from the same vessel or bucket and pigs from the same trough may be responsible for the transmission of the affection.

The proof of the transmissibility of the disease from one species to another was secured by Dammann,[9] who inoculated a bit of necrotic material from the mouth of a calf, dead with the disease, into the mouth of a four-days-old lamb. In four days the lamb died, with postmortem findings which established the success of the experiment.

It may safely be assumed that any species which has shown a susceptibility to the bacillus in any portion of the body may be attacked with necrotic stomatitis, the conditions for the inoculation of the germ being present.

The study of the transmissibility to man of necrotic stomatitis of animals involves not only the question of the pathogenicity for man of the infective agent of necrotic stomatitis, but also that other interesting and important question of the relation of animal diphtherias to man. This latter question will be treated separately. The former question is not really involved in the latter because, as we have shown, necrotic stomatitis is not a diphtheria. Still, of interest are the questions, Can man contract disease from cases of necrotic stomatitis in animals? Is *Bacillus necrophorus* pathogenic for man? An affirmative answer to the second makes probable an affirmative answer to the first.

No help in answering the questions can be gathered from Dammann's experiences, since in his cases it was also the question of a virulent micrococcus infection, and the sore throats in men referred to by him were no doubt infections of this sort. However, Schmorl records the case of himself and servant in the laboratory, both of whom developed small digital abscesses, in the contents of which were demonstrated both micrococci and undoubted forms of *Bacillus necrophorus*. When it is remembered that guinea pigs, ordinarily immune, may be successfully infected with *Bacillus necrophorus*, the tissues having been previously invaded by a micrococcus, it is readily seen that, under like circumstances in man, the necrosis bacillus might play the rôle of a secondary invader. Right here it must be remembered that, as already referred to, Löffler had met with *Bacillus necrophorus*, not only in his calf-diphtheria investigation, but also in some experiments looking toward the transmission to rabbits of syphilitic products. Out of four rabbits inoculated in the anterior chamber of the eye with bits of a condyloma latum, two died with local and metastatic necrosis, exhibiting the characteristic bacteriological pictures of *Bacillus necrophorus*. Löffler also makes the statement that he had several times seen, in addition to others, similar bacteria in the surface exudate of ulcerating condylomata lata, and that such bacteria were also present in the exudate of the inoculated condyloma. Jensen makes the suggestion that the deeply penetrating necroses, for example, of the intestine after typhoid and scarlet fevers, of the throat in scarlet fever, of the cheeks (noma) after scarlet fever, measles, etc., of the fingers in panaris, offer interesting fields of investigation with reference to the presence of *Bacillus necrophorus* in man.

Susceptibility.

Necrotic stomatitis attacks principally sucklings not over six weeks of age, but calves and pigs eight to ten months old are frequently

affected, and several cases of adult cattle showing the disease have been reported in the works of Bang,[1] Jensen,[30] Berg,[3] and others; also in two-years-old hogs in our correspondence from pig raisers. Moreover, Dammann,[10] Löffler,[42] and Diem [12] have noticed the natural occurrence of this affection in lambs. The presence of the disease in various other species has already been referred to in a previous chapter. Sex and breed play no rôle in reference to this malady, as it is not confined to either male or female nor to any particular breed or breeds.

Economic Importance.

Although occasional reports of a rapidly fatal disease affecting the mouths and throats of calves have been forwarded to this office from various sections of the West during several years past, no fresh material for an investigation into the nature and cause of the affection could be procured until 1902 and 1903, when a number of rather severe outbreaks occurred in Colorado, western South Dakota, and eastern Wyoming. From the history, symptoms, and lesions of the affected animals described in these letters, it seemed probable that the disease was the so-called calf diphtheria of Europe, but this suspicion could not be verified until specimens of the diseased heads of calves were received through Dr. A. B. McCapes, at that time State veterinarian of Colorado, to whom we extend our thanks. Very little is positively known of its prevalence in this country, owing to the lack of familiarity of stock owners and veterinarians with the disease, but it is doubtful if its appearance here is of recent origin. The very fact that the causative agent (*Bacillus necrophorus*) of this disease has also been isolated in this laboratory from abscesses in the livers of cattle slaughtered at Kansas City and Chicago, from the liver of a deer from the National Zoological Park, and from sheep affected with foot-rot, would indicate that the organism is widespread in this country, only awaiting an opportunity for entering the tissues of a susceptible animal.

In reviewing the economic importance of this disease, consideration must be given to the other infections produced by *Bacillus necrophorus*, some of which are even more grave than necrotic stomatitis. The presence of the latter disease on a farm would indicate the possibility of the causative germ affecting other susceptible animals in tissues already referred to in the chapter on pathogenesis. Thus the importance of this organism is far beyond even its relation to necrotic stomatitis of calves and pigs since foot-rot of cattle and sheep, necrotic inflammation of the uterus and vagina of cows, a similar inflammation of the large intestine, and necrotic scratches of horses, gangrenous processes of the lips and nose, and necrotic stomatitis in sheep, may all follow on premises contaminated with the infectious principle of this disease. Among the letters that have been received

requesting information relative to this malady, the following will convey a general idea of its nature and importance:

Within the last two weeks several complaints from different parts of the State, mostly from the mountain regions, have come into this office regarding a disease in calves that were dying from sore mouth. I have just returned from Gunnison, where I examined several calves that died of this disease. I found that at the base of the tongue and in the larynx there were large sores, some of them as large as a silver dollar. They presented a thickened croupous matter usually white in color. After this matter was scraped off with a knife, a red granulated membrane was left. The owner told me that in some cases these sores appeared on the anterior part of the tongue, but in the cases I saw they were at the base of this organ. The trouble occurs in sucking calves of one to three months old. The first symptoms noticed are that they can not swallow, and soon cease to nurse. In calves that are old enough to eat hay or other forage, large boluses of food are found between the lips and teeth, giving the appearance of a large swelling on the side of the face. Practically speaking, 90 per cent of the affected calves have died. One party lost 21, another 10, with no cases recovering on their farms.

Another correspondent from Salida, Colo., writes:

We have lost 33 calves with throat and mouth disease and will lose more.

A stock owner, writing from Lithia, S. Dak., states:

There is a disease attacking my calves and which is new to the cattlemen of this vicinity. The calves stop eating; about three days after they begin to foam at the mouth, but continue to move their mouths. The throat swells very hard and the jaws are set tight, so that they can not open. A foamy pus discharges from the nose two days before they die, and they seem to strangle to death from accumulation of this pus in the nose and throat. They have high temperature and stand up and lie down alternately during the last two days. The bowels move freely and there is a tendency to urinate frequently. Death occurs in four or five days. Upon cutting into the throat or larynx and nasal cavities, they were found completely filled with thick pus. The muscles around the larynx and throat and back and under the tongue seemed to resemble the contents of an abscess. The heart and lungs seemed to be in their natural condition. I now have 7 head that have this disease.

From Aladdin, Wyo., the following was received:

A disease has broken out among my calves. I have 117 head and I believe half of them have sore or ulcerated tongues. I can not see that they are affected otherwise. The sore is generally located on the top of the tongue about the center and in some cases has eaten the tongue nearly in two. Two head have died, and in one of them nearly the entire surface of the back half of the tongue had rotted away and contained numbers of cavities filled with pus, but I could not find any foreign substance in them.

A letter from Belle Fourche, S. Dak., indicates that the disease is amenable to treatment.

There are a number of herds (calves) affected in this country, and I know of 1 cow. I have been using boracic-acid wash for mine, and they seem to be improving.

A ranchman sends the following record of his observations from Bixby, S. Dak.:

All of my calves and some of my yearlings have some kind of a disease. Their jaws swell and sometimes their throats, and when I come to examine them I find

that their jaws are sore on the outside of the grinders and inside the cheek. In some it rots holes in their tongues, mostly at the back part. The breath smells terribly and the calves get dumpy and poor.

A letter from Masonville, Colo., suggests the possibility of the disease originating from foot-rot in cattle.

I should like your opinion of what might be called an epidemic among my calves. Three of them have been attacked with swellings in the lower jaw on both sides. Yesterday one of the calves died, and on examining the jaw I found it apparently rotten on the inside from the grinders down. There was no pus. Last summer I noticed a calf of this same herd similarly afflicted, but it came out all right. Last summer about 10 per cent of my cattle were troubled with their feet cracking between the hoofs. They became very lame.

Mr. G., of Wheatland, Wyo., requested—

information regarding some young calves I have. There are 2 calves less than a month old running with their mothers. One of them has his jaw swollen up on one side. The other calf has both sides of the jaw and under the jaw swollen. I examined their mouths and found "canker" alongside and behind their teeth, and it was awfully offensive. A few weeks ago I lost one six-months-old calf with a similar disease.

Many cases of sore mouth in pigs are reported from various sections of this country, and, assuming that these cases were similar to those investigated by us, it would seem that this disease causes the death of many young animals and also stunts the growth of many that survive. Almost every pig in the litter suffers, and litter after litter becomes affected. The same lack of recognition of the disease as in calves prevents any accurate description of the importance of the affection in pigs, but in a few outbreaks observed it was noted that from 60 to 90 per cent of the animals in the herd died if left untreated. The disease in pigs, while usually affecting the young, has been reported at all ages, from sucking pigs one week old to hogs two years of age. One writer reports a loss of 33 out of 50, another 33 out of 37, while a third states that of 12 four-months-old shoats 11 succumbed to the disease.

Differential Diagnosis.

Necrotic stomatitis may be differentiated from foot-and-mouth disease by the fact that in the latter malady there is a rapid infection of the entire herd, as well as of any hogs or sheep that may be on the premises; it is also highly infectious, spreading rapidly to neighboring herds and to cattle of the same herd. The characteristic lesion of foot-and-mouth disease is the appearance of vesicles containing serous fluid in the mouth, upon the udder, teats, heels, and coronary bands of the affected animals. Drooling is profuse, and there is a peculiar smacking sound made by sucking the affected lips. In hogs the mouth is not so likely to be affected as are the feet. Foot-and-mouth

disease has appeared in this country on four occasions only, always near a seaport, and does not exist in the United States at the present time. In necrotic stomatitis vesicles are never formed, necrosis occurring from the beginning and followed by the formation of yellowish patches, principally in the mouth.

Mycotic stomatitis is a sporadic disease which affects cattle of all ages that are on pasture, but more especially adult animals. It is characterized by inflammation and ulceration of the mucous membranes of the mouth, producing salivation and inappetence, and, secondarily, affecting the feet, which become sore and swollen. Superficial erosions of the skin, particularly of the muzzle, and of the teats and udder of cows may also be present. It occurs only in a few animals of the herd, usually in the early fall after a dry summer; it does not run a regular course and can not be inoculated.

Actinomycosis of the tongue may occur as superficial erosions but is usually deep-seated, where, instead of producing ulceration and destruction of the mucous membrane, it causes a diffused induration of the muscular tissue of the tongue, resulting in an enlargement of that organ. Hence the term "wooden tongue" has been applied to this condition. The course of the disease is chronic and the tongue is extensively affected before attracting the attention of the owner. The indurated tissue when incised is found to be hard and gritty and contains bright yellow sulphur-like granules of actinomyces, which are the causative agents of the disease.

Prognosis.

Ordinarily animals affected with necrotic stomatitis show no tendency to spontaneous cure. Left to themselves, they either die or become permanently stunted in growth. On the contrary, if taken in hand early, the disease is readily amenable to treatment. In the latter event the prospects of recovery are excellent, and under favorable conditions it takes place as a rule in twelve to fifteen days.

Treatment.

PROPHYLAXIS.

Prophylaxis should be carried out along three lines: (1) Separation of the sick from the healthy animals; (2) close scrutiny and thorough disinfection once daily for five days of the mouths and nasal passages of those animals that have been exposed by the eruption of the first teeth, by the shedding of the milk teeth, or through association with affected animals; (3) complete disinfection of all stalls, sheds, and

farrowing pens with a 5 per cent solution of carbolic acid to which has been added sufficient lime to make the disinfected area conspicuous.

The disease apparently breaks out in winter and holds over to spring. It is conceivable that exposure to cold might so disturb the normal circulation of the oral tissues as to make the mucous membrane an excellent location for the development of the causative factor of the disease. There is another possibility, however, which bears on the third line of prophylaxis. The diphtheric inflammation of the vagina and uterus in cows is caused by the same organism that induces necrotic stomatitis. Ellinger[13] has recently pointed out the almost constant relation of such attacks to previous occurrences of foul-foot or foot-rot in the same or other cattle on the place. In all likelihood, the stalls and sheds are the harborers, in such cases, of this germ. Why may it not be that many of these outbreaks of necrotic stomatitis in calves have some relation to preceding cases of the above-mentioned diseases and the greater use in winter of stalls and sheds harboring the *Bacillus necrophorus;* and in pigs to the fact of their following cattle affected with one of the above diseases?

THERAPEUTICS.

The treatment consists almost solely in careful and extensive cleansing and disinfection of the mouth and other affected surfaces. The mucous membrane of the mouth should be copiously irrigated with a 2 per cent creolin solution in warm water. This should be performed at least twice daily, but care should be used with this as with all other antiseptics, to prevent swallowing of any considerable quantity of the solution. Since exposure to oxygen kills the bacilli one need have no fear about disturbing or tearing off the caseous patches or necrotic tissue during irrigation. The irrigation of the sores should be followed by the application with a brush or rag on a stick of a paste made with salicylic acid 1 part and glycerin 10 parts; or the affected spots may be painted with Lugol's solution of iodine (iodine 1, potassium iodide 5, water 200). Frequent injections into the mouth of a 1 per cent carbolic-acid solution make an excellent treatment. In calves the internal administration of 2 grams of salicylic acid and 3 grams of chlorate of potash three times a day has also proved very beneficial.

A very simple and efficacious method of treating pigs is to catch them and hold their heads for a few moments in a solution containing in each gallon of water 2 ounces of potassium permanganate, or in a solution of creolin of like strength. This treatment may be repeated twice daily for six days.

If the predisposed animals are sucking, it would also be advisable to bathe the udder and teats of the cows or sows with a 5 per cent solu-

tion of carbolic acid in order to prevent infection from the probably contaminated manure on these parts. In animals that have been weaned it will be necessary to feed soft, nutritious food, such as whole milk, bran mashes, ground feed, and gruels, and to keep clean, cool water constantly within reach.

Relation of Animal Diphtherias to Man.

We have already shown that the cause of necrotic stomatitis and the cause of human diphtheria are entirely distinct microorganisms. We have also shown that the disease process in necrotic stomatitis of animals is markedly different from that in human diphtheria. A superficial resemblance in the local manifestations of the two diseases and a total misconception of the cause of each gave rise to an identity of terms which is confusing. As we have elsewhere stated, calf diphtheria is a misnomer, false in its characterization of the disease, and misleading in its effect upon the mind of the public. The same statement holds with reference to so-called chicken diphtheria, or roup, and similar affections in avian species. Many different species of the mammifers have revealed disease processes in mouth and throat that superficially resemble the diphtheritic process in man, but the weight of evidence at the present time goes to show that the pathological alteration in many of these cases is not identical with that in human diphtheria. However, satisfactory proof has been offered of the recovery of the bacillus of diphtheria from a few isolated cases, especially in the cat, horse, and dog. At this point we would remind the reader that in the human family diseases of the mouth, throat, and upper air passages frequently arise which closely simulate diphtheria, giving rise to almost identical clinical manifestations, but which upon bacteriological examination fail to yield the Klebs-Löffler bacillus, thus proving them to be distinct from diphtheria. In view of the apparent resemblance between the true and false diphtherias of man and animals, and because the former disease appears to be intercommunicable between man and animals, we urge upon the reader the isolation of all animals, particularly pets, affected with mouth and throat diseases, and the most punctilious observance of all details of sanitary precautions.

Disposition of Meat of Affected Carcasses.

If necrotic stomatitis were transmissible to man, the germicidal action of cooking might be counted on to obviate such danger. Proof that necrotic stomatitis is not transmissible to man does not demonstrate that the meat of animals so affected is fit for food. Other factors enter into this question of the edibility of such meat. The disease may be regarded as at the first a local affection. Now it is manifest

that those portions of the animal body affected with caseonecrotic patches should be condemned for food. The remaining portions of the carcass, however, if in a good state of nutrition, might be placed on the market.

On the other hand, should the disease have progressed beyond the condition of localization to a condition of toxinemia, which would be evidenced by emaciation, enlargement and discoloration of the lymph nodes, and cloudy swelling of the liver, the carcass should be rejected as both innutritious and noxious.

Conclusion.

We may note that in necrotic stomatitis of animals we have to do with an acute, infectious inflammation of the mouth and upper air passages, of widespread occurrence both geographically and zoologically, caused by the invasion locally of a thread bacterium, the *Bacillus necrophorus*, a nonmotile, polymorphic anaerobe, inhabiting normally the intestinal tract of hogs and, in all probability, of herbivora, and found also in manure.

The disease is observed most frequently in calves and pigs, and usually in connection with the eruption of the first teeth, although other injuries of the mucous membranes may be the starting point. The disease process is a clearly defined cheesy degeneration of a progressive coagulation necrosis characterized by the formation of ulcers and caseonecrotic patches, and manifesting itself clinically by salivation, refusal to suck, difficult breathing, and rapid emaciation. The duration of the disease is from five days to five weeks, these animals, if untreated, dying early with a toxinemia. Necrotic stomatitis is not difficult of diagnosis and may quite easily be differentiated from other inflammations of the mouth, is most amenable to treatment, and hence offers a highly favorable prognosis. The exquisitely infectious nature of the cause rendering most easy the rapid development of an enzootic, and favoring the spread of other forms of bacillary necrosis, some of them even more grave than necrotic stomatitis, lifts the disease to a high place in agricultural economics. It appears to be transmissible to man, but it is absolutely distinct from human diphtheria.[a]

[a] Presumptive evidence as to the possibility of necrotic stomatitis occurring in man is offered by an experience of Jensen's. In the Copenhagen Zoological Gardens there occurred among the monkeys an epidemic apparently of scurvy. In several cases the mouth showed ulcerative processes in which was demonstrated the bacillus of necrosis. The most important observation bearing on this subject is published this year (1905) by Ellermann (Centralbl. f. Bakt. 1 Abt. Orig. xxxviii, 4, p. 383). A 9-months old infant had died with symptoms of laryngitis and pneumonia. Necropsy revealed faucial, pharangeal, and laryngeal pseudo-diphtheria. Sections of the uvula showed a deeply penetrating necrosis with a felt of long thread-like bacilli on the border of the living tissue. Differential staining of the bacillus, the biologic character of the necrosis, together with the fact that pneumonia developed secondarily in the disease, lead Ellermann to assume a primary infection with *Bacillus necrophorus*.

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